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EASTERN ISHTAR TERRA: TECTONIC EVOLUTION DERIVED FROM RECOGNIZED FEATURES.

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Introduction: Previous analyses have recognized several styles and orientations of compressional deformation, crustal convergence, and crustal thickening in Eastern Ishtar Terra [1-11]. An east to west sense of crustal convergence through small-scale folding, thrusting, and buckling is reflected in the high topography and ridge-and valley morphology of Maxwell Montes and the adjacent portion of Fortuna Tessera [5-11]. This east to west convergence was accompanied by up to 1000 km of lateral motion and large-scale strike-slip faulting within two converging shear zones which has resulted in the present morphology of Maxwell Montes [5-7]. A more northeast to southwest sense of convergence through large-scale buckling and imbrication is reflected in large, northwest-trending scarps along the entire northern boundary of Ishtar Terra, with up to 2 km of relief present at many of the scarps [11,12]. We have previously suggested that both styles of compression have occurred at the expense of pre-existing tessera regions which have then been overprinted by the latest convergence event [11]. The difference in style is attributed mostly to differences in the properties of the crust converging with the tessera blocks. If one, presumably thick, tessera block converges with another tessera region, then the widespread, distributed style of deformation occurs, as observed in western Fortuna Tessera. However, if relatively thin crust (such as suggested for the North Polar Plains [13]) converges with thicker tessera regions, then localized deformation occurs, as reflected in the scarps along Northern Ishtar Terra.

Our purpose in this abstract is to identify the types of features observed in Eastern Ishtar Terra. In this abstract and the accompanying poster presentation, we will describe their potential temporal and spatial relationships, suggest possible origins for them, and show how the interpretation of some of these features has led to the multiple-style tectonic evolution model described above.

Craters - These are elliptical or circular depressions described and interpreted as impact craters by Basilevsky and others [14]. They include: Cleopatra (66N/7E), Fernandez (76N/17E), Rossetti (57N/7E), Unnamed #1 (75.5N/30E), Ulrique (76N/55.5E), Frida (68N/55.5E), Unnamed #2 (66.5N/58E).

Montes - Recognized as a very high relief rise or chain of rises [15], these mountain ranges are characterized by sub-parallel linear ridges and valleys that strike parallel to the trend of the rise and by linear features that cut across the trend of the ridges and valleys. The ridges and valleys have been interpreted as compressional features [1, 3-5, 16] and the linear features as strike-slip faults [5, 16]. The only major mountain chain in Eastern Ishtar Terra is Maxwell Montes, centered at 65N/4E.

Dorsae (Ridge Belts) - Ridge belts are similar to montes in that they are characterized by sub-parallel linear ridges and valleys often cut by linear features. However, they differ from montes in that they are more irregular in plan [15] and have less topographic relief (always less than 3 km). The nature of these features is uncertain, with compressional [17], extensional [18], and transpressional origins all possible. Those in and around Eastern Ishtar Terra include: Semuni (70N/3E-78N/12E), Dyan-Mu (78N/28E-75N/43E), Sel-Anya (84N/75E-75N/80E), Allat (60N/65E-65N/80E), Kamari (62N/45E-50N/60E), Ausra (45N/20E-55N/28E), Auska (59N/356E-62N/2E), and Unnamed #1 (76.5N/56E-71N/84E).

Rupes (Scarps) - These steep scarps are often up to thousands of km long and can have over 2 km of relief. They commonly occur along the edges of highland and tessera areas, often separating regions of highly deformed terrain (such as tessera) from relatively less deformed areas (such as smooth plains). The nature of these scarps is variable, with some scarps interpreted to be related to compressional deformation involving large-scale crustal buckling, imbrication, and underthrusting [12,13], while others may represent fault surfaces associated with rifting [19]. Several dozen unnamed scarps over 100 km long have been mapped in Eastern Ishtar Terra [11], with particular concentrations occurring along the northern and eastern flanks and in the central portion of this region (see chasmata).

Chasmata - Chasmata are deep, steep-sided linear depressions [15] with flat floors that are often covered by relatively smooth plains units. Parallel, inward-facing scarps, with up to 2 km of relief define the boundaries of chasmata, which can be up to 100 km wide and over 1000 km long. The nature of these features is also uncertain, since some have been interpreted as extensional graben [19], while others may represent incipient suture zones between converging crustal blocks or slices [12]. Those recognized in and around Eastern Ishtar Terra include: Morana (67N/25E-71N/25E), Varz (71N/27E-70N/30E), Lasdona (66N/30E-72N/35E), Daura (74N/50E-73N/55E), Aranyani (73N/73E-68N/74E), Unnamed #1 (73N/28E-69N/38E), Unnamed #2 (68N/27E-72N/34E), Unnamed #3 (71N/40E-73N/47E).

Fossae - Fossae are long, linear, narrow, shallow, depressions [15]. They differ from chasmata in that they are very narrow (less than 20 km wide) and lack flat floors. A simple extensional origin is favored for most of these features, but some may be graben related to large-scale shearing [4], while others (not previously identified as fossae, but as 'troughs') may represent strike-slip or shear faults [11]. Three major sets of fossae are recognized around Eastern Ishtar: Sigrun (48N/17E-53N/19E), Rangrid (63N/355E-62N/0E), and Manto (~63N/54E-64N/69E).

Syntaxes (No official nomenclature) - Syntaxes on Venus are broad, arcuate, loop-like features converging at the apical end and opening at the antapical end, with lengths of 250-600 km and widths of 100-400 km [20]. Individual

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ridges and valleys between 5 and 20 km wide and 20 and 300 km long define the interiors of these features. On Earth, they represent a bend in an orogenic belt, such that two or more compressional (ridge) trends form an acute angle at their intersection. Two such features are recognized in Eastern Ishtar, including: Unnamed #1 (south-opening, apex at 65N/22E) and Unnamed #2 (south-opening, apex at 73N/75E).

Septae - These features are broad linear rises, often bounded by steep rupes. They exhibit a mottled appearance dominated by very narrow (< 5 km) intersecting ridges and/or fossae. Their origin is uncertain. Three are recognized in Eastern Ishtar: Unnamed #1 (64.5N/32E-64.5N/37E), Unnamed #2 (64N/31E-63N/33E), and Unnamed #3 (67N/50E-68N/65E).

Basins - These are broad topographic depressions often bounded by steep scarps, but far less linear than chasmata. They are usually floored by smooth plains areas, although disrupted areas are often observed within them. Those basins in and around Eastern Ishtar include: Snegoruchka Planitia (North Polar Plains), Audra Planitia (southeast of Ishtar), Unnamed #1 (centered at 58N/5E, just south of Maxwell Montes), Unnamed #2 (centered at 69N/355E, just north of Maxwell), Unnamed #3 (74N/9E), Unnamed #4 (72N/11E), Unnamed #5 (65N/26E), and Unnamed #6 (61N/32E).

Chevrons (No official nomenclature) - Chevrons are curved features that consist of either individual or paired scarps, that are distinct from rupes or chasmata because they exhibit a sharp change in trend that produces an acute angle [8]. Numerous chevrons are observed concentrated in central Fortuna Tessera [8], where they may represent either syntaxes-like structures or the sharp edges of individual tectonic blocks. One such chevron opens to the south at 72N/26E.

Tesserae - Tesserae are regions of orthogonal to obliquely oriented sets of ridges and valleys [1]. Three sub-types of tessera have been identified on Venus [21], including: *Sub-parallel ridged terrain* (**Tsr**), *Trough and ridge terrain* (**Ttr**), and *Disrupted Terrain* (**Tds**). **Tsr** consists of sub-parallel ridges and valleys, often disrupted along linear zones, possibly indicating strike-slip offset. **Ttr** consists of parallel troughs separated by regions of parallel ridges and valleys oriented orthogonal to the troughs. **Tds** lacks continuous ridges or valleys and is often characterized by a blocky appearance. Tesserae occur as either individual blocks of one sub-type or as large regions made up of a collage or mosaic of tessera blocks and sub-types. Eastern Ishtar Terra represents one such collage region, with all three sub-types recognized there: **Tsr** is recognized just east of Maxwell Montes (65N/15E); **Ttr** in Eastern Fortuna (70N/59E); and **Tds** in Central Fortuna (68N/45E). The origin of tessera is uncertain, though a variety of models have been suggested [22]. We have previously interpreted the **Tsr** as resulting from the overprinting of the **Ttr** through compressional deformation oriented normal to the strike of the ridges and valleys in the **Tsr** [11]. This is reflected in the gentle transition from the **Ttr** pattern to that of the **Tsr** in Eastern Fortuna. Similarly, the **Tds** may result from the gravitational relaxation of **Ttr** or **Tsr** in Central Fortuna. In these ways, one tessera sub-type may be transformed to another.

Discussion. In our previous analyses we have interpreted the deformation in most of Eastern Ishtar Terra to be the result of several styles and orientations of compressional deformation and crustal thickening [5-11]. The various features in Eastern Ishtar Terra and their relationships to one another reflect these different styles and orientations. The sub-parallel ridges and valleys of Maxwell Montes and the Sub-parallel ridged terrain (tessera) of western Fortuna Tessera reflect an east-west sense of convergence in this region, with deformation characterized by small-scale folding and buckling [5-11]. This sense of convergence may also be reflected in the north-south orientation of the syntaxis structure at 66N/22E, as well as the numerous north-south chevrons in Central Fortuna Tessera [8], and in the north-south trend of Semuni Dorsa [9,10]. The more northeast-southwest sense of convergence suggested for Northern Ishtar Terra is predominantly characterized by large-scale buckling and crustal imbrication, which is reflected in the sub-parallel rupes, chasmata, and dorsae striking west-northwest along this boundary [11-13]. Present analysis is focused on the detailed mapping and synthesis of the units, features, and their relationships.

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